Exploring Molecular Complexity of the Diffuse and Translucent Gas and Photo-Dissociation Regions

Completed Technology Project (2018 - 2020)

Project Introduction

This proposal requests funds to continue a laboratory program in close coordination with radio astronomical observations dedicated to the study of highly reactive polyatomic molecular ions in low density regions and photo-dissociation regions (PDRs). In doing so, the proposed studies will advance our understanding of the chemistry beyond light ions that have been observed so successfully in these regions with Herschel and recently extended with SOFIA, and thereby critically address a significant but unresolved question in molecular astronomy: Are larger molecules formed in a bottom-up or top-down chemistry? The rotational spectra of most new molecular ions will be detected in the laboratory in a resonant microwave cavity, followed either by microwave/millimeter-wave double resonance or millimeter/THz absorption to better characterize their spectrum in bands covered by the heterodyne receivers HIFI on Herschel and GREAT on SOFIA. In collaboration with radioastronomer colleagues, we will search for the new ions in the published survey of the PDR region of the Orion~Bar and archival data of other PDRs observed with the IRAM 30 m telescope; retrieve and analyze archival data from Herschel; and undertake searches for some of the new ions in PDRs and low density regions with SOFIA. This work will also have a strong bearing on proposed Early Release Science (ERS) observations of dense PDRs with the James Webb Space Telescope (JWST). The laboratory effort will build on previous work on molecular ions , specifically detection of the rotational spectra of a number of positive ions of astronomical interest such as H2NCO+, CCCH+, the cis- and trans isomers of HOSO+, HNCOH+, and H2CC(H)CNH+. We will focus our efforts on positive ions derived from closed-shell neutral molecules, radicals, and carbenes whose rotational spectra have been observed in our laboratory, and nearly all of which have also been identified in galactic molecular clouds. Examples of the ions we seek include polyatomic ions such as CN+, HCCCN+, HNCO+, c-C3H2+, etc. Collaborations with leading theoretical groups to accurately predict spectroscopic constants of the new ions will enhance the proposed laboratory investigations. Instrumental refinement will also be undertaken with particular emphasis on construction of a new cryogenically cooled (~6 K) buffer gas cell. This ultra-sensitive instrument will possess a system temperature that is nearly 50 times lower than our most sensitive cavity spectrometer, and one close to the fundamental limit set by modern technology, thereby greatly enhancing our ability to detect elusive molecular ions that are produced in very low steady state concentrations. The essential capabilities of this instrument have already been demonstrated in collaborative investigations. Our laboratory program is well aligned with NASA's overall mission, because we seek to understand the role of the chemical bond on a cosmic scale and to provide a firm chemical foundation by which more complicated questions of biological origins can be addressed. The work here also provides much basic information to aid subsequent astronomical searches, particularly in the infrared. Finally, our research program is an excellent vehicle for integrating research and education. It provides exposure to quite diverse areas of science in a setting

Exploring Molecular Complexity of the Diffuse and Translucent Gas and Photo-Dissociation Regions

Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Smithsonian Institution

Responsible Program:

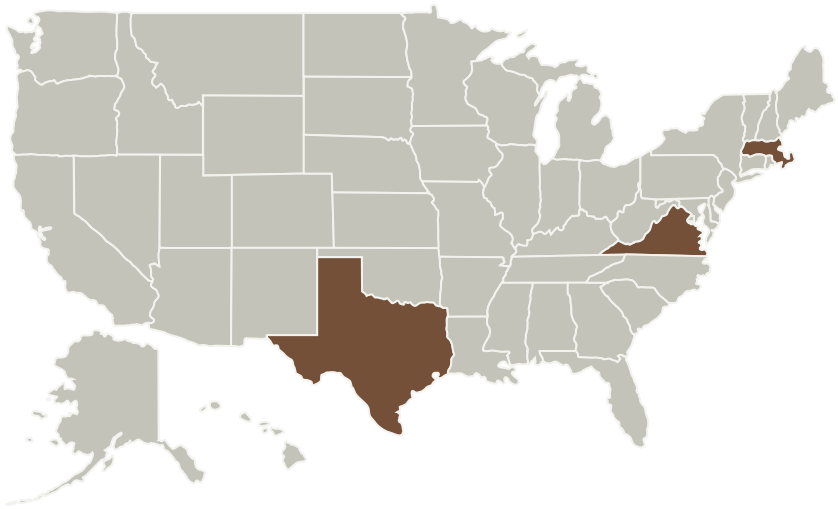
Astrophysics Research and Analysis

Exploring Molecular Complexity of the Diffuse and Translucent Gas and Photo-Dissociation Regions

Completed Technology Project (2018 - 2020)

which encourages student initiative and independent investigation.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Smithsonian Institution	Lead Organization	Industry	Washington, District of Columbia
National Science Foundation	Supporting Organization	US Government	
Smithsonian Astrophysical Observatory(SAO)	Supporting Organization	US Government	Cambridge, Massachusetts
The University of Texas at Austin	Supporting Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	Austin, Texas

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Michael C Mccarthy

Co-Investigators:

Carl A Gottlieb
John F Stanton
Jill Robidoux
Harshal Gupta
Jose Cernicharo
Marcelino Agundez

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.1 Field and Particle Detectors

Target Destination

Outside the Solar System

Exploring Molecular Complexity of the Diffuse and Translucent Gas and Photo-Dissociation Regions

Completed Technology Project (2018 - 2020)

Primary U.S. Work Locations	
Massachusetts	Texas
Virginia	